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The Effects of Isometric Exercises on Underhand Throwing Ability.

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THE EFFECTS OF ISOMETRIC EXERCISES ON UNDERHAND THROWING ABILITY

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ABSTRACT

Many questions remain unanswered regarding the effects of isometric exercises. There is much research on file to substantiate the fact that isometric exercises do produce strength gains. There is still much to learn concerning the effects of other factors which are the components of physical proficiency. The purpose of this research was to determine the effects of functional isometric exercises on throwing a softball for maximum distance and also to continue throwing a softball for maximum distance. The performance tested was eighty softball throws for maximum distance.

Four groups of twenty college males served as subjects for the study. One group practiced isometric exercises only. A second group practiced isometric exercises and also practiced throwing a softball for maximum distance eighty times, three days a week. Another group practiced throwing a softball for maximum distance eighty times, three days a week, and did not practice isometric exercises. A fourth group served as a control group and did not practice isometric exercises or throwing a softball for maximum distance. All subjects were pre-tested, underwent a six-week training period, and then were post-tested. Each subject tested threw a softball for distance eighty times. Throws were made every six seconds and distances were recorded in feet.

In order to determine whether strength was attained as a result

of isometric exercises or other uncontrolled factors, the pre-test and post-test also included strength recordings of one arm position within the range-of-motion of a softball throw and a recording of the dominant leg in a position which approximated a "push off" execution in throwing a softball. Once the training program began, subjects assigned to exercise groups were tested weekly and notified of their progress for purpose of motivation.

A Type III statistical design was used to analyze the data collected. The pre-test data were analyzed by analysis of variance. Since no significant differences were found when comparing the four groups, only the post-test data were used. This analysis revealed no significant differences between the triple-action of exercise groups, throw groups, and total trials by subjects. When exercise groups were compared to no-exercise groups, no significant difference was found at the .05 level. Throw groups performed significantly greater at the .01 level when compared to the exercise groups; however, the interaction of the two, when compared, evidenced no significant difference.

When exercise groups were compared to no-exercise groups in their ability to throw a softball for maximum distance, an "F" ratio of 3.93 was found. Although this failed to meet the required "F" ratio of 3.97 for the .05 level of probability, this realized "F" ratio was considered high.

The differences of means between the first through the fourth

group of twenty throws were determined by analysis of variance for both the exercise group and the no-exercise group. The exercise group did not experience a significant decline from one group of twenty throws to the fourth group of twenty throws. The no-exercise group, however, experienced a significant decline, indicated by an "F" ratio of 15.93, which was found to be linear in nature.

This study justifies the following conclusions:

1. Functional isometric exercises will improve the ability to maintain the maximum distance thrown.
2. The addition of a functional isometric exercise program to a throwing-for-distance program will produce positive gains beyond that of a throwing program alone.
3. A program of practice throwing for maximum distance will improve the ability to throw for maximum distance.
4. A program of isometric exercises will bring about significant improvements in strength.
5. Practicing throwing a softball for maximum distance, without isometric exercises, will improve leg strength.

CHAPTER I

INTRODUCTION

The development of strength and the search for ways to better perform physical feats have long been important to man. The complexities that are present in the human organism are many. Although much research has been undertaken to ascertain what programs of strength building are best, how long it takes to increase strength, how fast a person loses strength and other problems regarding this vast area of knowledge, there remain many unanswered questions regarding the development of volitional muscle strength.

In recent years athletic coaches have come to place a high regard on the development of strength. The traditional weight training programs which had been used in the past have witnessed a counterpart on the scene in the name of isometric exercises. Much research has been undertaken that concludes that isometric exercises can be of value in strength attainment (see Chapter II). Perhaps there are other conditioning programs that need to be pursued. Research should be continued so that one day the proper training program, the proper time, sequence, implementation and utilization of both isometric and isotonic exercises can best serve each individual's need for efficient improvement of his physical performance.

I. PURPOSE OF THE STUDY

It was the purpose of this study to determine the effects of

functional isometric exercises on the following: (1) the ability to throw a softball underhand for maximum distance; and (2) the ability to continue throwing a softball underhand for maximum distance.

II. SIGNIFICANCE OF THE STUDY

There is a great deal that must be learned regarding the proper training routines and programs. There is a greater need for answering questions that heretofore have not been undertaken regarding time, sequence, and effect of strength improvement on athletic performance. This is true in ballistic type athletic events. Any evidence that may either support or reject the use of isometric exercises will ultimately lead to a safer, wiser, and more scientific approach to the teaching of physical activity.

III. LIMITATIONS OF THE STUDY

This study was done utilizing a six-week training program. The subjects were limited to a three-day-a-week training program.

Eighty subjects were used and although perfect attendance was realized on the part of all the subjects, there was evidence that on occasion some subjects reported to class and participated although they had colds and had had an insufficient amount of sleep. This was not excessive, nor did any student ever participate who, in the writer's opinion, was too ill to attend class.

On five occasions the classes had to refrain from outdoor activity and participate in a university field house. The four

groups continued, however, in the training program and regular class activity.

IV. BASIC ASSUMPTIONS

It was assumed that the eighty participants would display a great deal of cooperation and interest throughout the study. Although outside activities were recognized as being possible factors in altering the progress of the participants, it was assumed that each subject cooperated while outside of class and did not engage in activities that would have altered his progress during the training period.

It was also assumed that each subject was equally motivated to perform up to maximum ability during both testing sessions and the entire training session which were undertaken in this study.

V. DEFINITION OF TERMS USED

Isometric Contraction. Development of tension without a shortening of the muscle fiber.[1]

Softball Throw. An underhanded throw with the dominant arm. The execution is performed as a result of a stride step and a 360-degree arm swing and release.

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[1]Laurence E. Morehouse and Augustus T. Miller, Jr., Physiology of Exercise (St. Louis: The C. V. Mosby Co., 1959), p. 27.

Functional Isometric Contraction. An isometric contraction with the muscle exerted in a position approximating that of a desired activity.

CHAPTER II

REVIEW OF RELATED LITERATURE

There have been many studies made regarding the effects of isometric exercises. The majority of these research studies have been undertaken to determine strength gain effects of isometric exercises. In presenting the related literature, an attempt was made to list those studies pertinent to the immediate problem at hand. The three areas with which this research study was concerned are presented under the following headings: (1) Studies Related to Isometric Strength Gains; (2) Studies Related to Isometric Programs and Movement; and (3) Studies Related to the Effect of Isometric Exercises and Endurance.

I. STUDIES RELATED TO ISOMETRIC STRENGTH GAINS

Research studies have indicated that isometric exercises do promote the attainment of strength.

Rarick and Larsen[1] found that a single, daily six-second isometric exercise done at two-thirds maximum tension is as effective as more frequent and more intense periods of isometric exercises.

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[1]Lawrence Rarick and Gene L. Larsen, "Observation on Frequency and Intensity of Isometric Muscular Effort in Developing Muscular Strength," Research Quarterly, XXIX (October, 1958), 333-341.

Strength retention was realized, however, in the group exercising more frequently and with more intense isometric contractions.

In an experimental study undertaken at the University of Iowa, Wolbers and Sills[2] conducted an eight-week program using high school boys. Two groups of boys were given four tests of strength prior to and at the conclusion of the eight-week period. The experimental group was given exercises in the nature of static muscle contractions. It was found that the static contractions produced a gain in strength significantly greater than the control group. The experimental group consisted of ten subjects and during each daily meeting for eight weeks, an all-out effort was encouraged. The experimental group made greater gains in back lift, leg lift, and the combined hand grip test than the control group. The conclusions were that static muscle contractions of six-second duration cause significant gains in strength and that one six-second isometric contraction per day will produce significant gains in strength.

Taylor[3] compared four isometric exercise programs in 1954: (1) a maximum pull for twelve seconds; (2) a maximum pull for six seconds; (3) a two-thirds maximum pull for twelve seconds; and (4) a two-thirds maximum pull for six seconds. The specific conclusions were:

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[2]Charles P. Wolbers and Frank D. Sills, "Development of Strength in High School Boys by Static Muscle Contractions," Research Quarterly, XXVII (December, 1956), 446-455.

[3]William Edward Taylor, "A Study Comparing the Effectiveness of Four Static Contraction Training Methods for Increasing the Contractile Strength of Two Body Movements" (unpublished M.S. thesis, Pennsylvania State University, 1954), 86 pp.

1. There was no significant difference among the four static contraction methods used for the purpose of increasing the contractile strength of muscles involved in movement of right wrist dorsal-flexion.
2. The training method of "two-thirds maximum for six seconds" was significantly better, at the .05 level of confidence, than "two-thirds maximum for twelve seconds" for the purpose of increasing the contractile strength of the muscles involved in the movement of right hip outward rotation.
3. With the exception of that noted in the preceding conclusion, no one of four static contraction methods was significantly better than each of the others for the purpose of increasing the contractile strength of muscles involved in movement of the right hip outward rotation.
4. All of the training methods, with the exception of "two-thirds maximum for twelve seconds," produced a significant improvement in the contractile strength of muscles involved in movement of right wrist dorsal-flexion, in comparison with the contractile strength of the same muscles of a non-trained control group.
5. Two of the four training methods, "maximum pull for twelve seconds" and "two-thirds maximum for six seconds," produced a significant improvement in right hand outward rotation strength, in comparison with the strength of the control group.

6. The difference in favor of the experimental groups over the control group did not always result in a critical ratio significant at the .05 level, but in every case there was a higher group mean for the experimental group than for the control group.

Barham[4] used ninety subjects recruited from physical education activity classes to compare the effectiveness of isometric and isotonic exercises when performed at different frequencies per week in the improvement of muscle strength performance.

Six experimental groups of fifteen subjects in each group were used. Three groups were given isometric exercises and three groups were given isotonic exercises. The six groups undertook exercise programs ranging from two to five days a week.

Initial and final strength tests were given and the difference of the two tests was used to determine the effects of the six training programs. It was concluded that:

1. Significant improvement in muscle strength performance may be achieved through the use of isometric methods of exercise.
2. The addition of isotonic exercises to one maximum isometric exercise does not significantly affect the amount of

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[4]Jerry N. Barham, "A Comparison of the Effectiveness of Isometric and Isotonic Exercises when Performed at Different Frequencies per Week" (Doctoral dissertation, Louisiana State University, Baton Rouge, 1960), p. 56.

strength improvement obtained through the use of isometric exercises alone.

3. There is no significant difference in the amount of strength acquired through exercises performed five days a week and the amount of strength acquired through exercises performed three days a week.

4. The amount of strength acquired through exercises performed five days a week and three days a week is significantly greater than the amount of strength acquired through exercises performed two days a week.

New insights and added interest in training with isometric exercises began after the experiments and publications of Mueller and Hettinger.[5]

These two researchers intensified efforts over an eighteen month period using nine male subjects in seventy-one separate experiments in which training took the form of pulling and holding a predetermined amount of tension against a spring scale, by contracting the flexors and extensors of the forearm. Training schedules ran five days a week and strength tests were recorded on the sixth day.

The findings of Hettinger and Mueller have been summarized by Steinhaus.[6] This summary is inclusive up to 1955. Since 1955, many

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[5]Theodor Hettinger and E. A. Mueller, "Muskelleistung and Muskeltraining," Arbeitsphysiologie, XV (1953), 111-126.

[6]Arthur Steinhaus, "Strength from Morpurgo to Muller--A Half Century of Research," Journal of Association for Physical and Mental Rehabilitation, IX (September - October, 1955), 147-150.

of the earlier viewpoints projected by Mueller and Hettinger have been modified by Mueller[7,8] and in a recent book by Hettinger.[9] Some of the more important recent conclusions are:

1. The maximum training effect possible was achieved by using only forty to fifty per cent of the maximum strength in voluntary isometric muscle contractions.
2. No increases or decreases in strength are observed when only twenty to thirty per cent muscle strength is used. This percentage of muscular exertion would appear to approximate normal daily activity during which mere repetition of the same sub-maximal effort causes no increase or decrease in muscle strength.
3. Gradual losses in muscle strength occur when less than twenty per cent of muscle is used.
4. Complete muscular fatigue is not necessary to promote muscle strength.
5. A maximum isometric contraction for only one to two seconds is sufficient to provide a training stimulus. A contraction of only two-thirds of the maximum strength should be

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[7]E. A. Mueller, "Training Muscle Strength," Ergonomics, II (February, 1959).

[8]E. A. Mueller, K. Velter, E. Blumel, "Transport by Muscle Power Over Short Distances," Ergonomics, I (May, 1958), 222.

[9]Theodor Hettinger, Physiology of Strength (Springfield, Illinois: Charles C. Thomas, Bannerstone House, 1961).

maintained for approximately four to six seconds. Muscular contractions of very short durations have no effect on strength promotion.

6. It was found that the maximum increase in muscle strength was obtained with one training stimulus per day.

7. Several maximum contractions in succession did not increase strength over one maximum contraction.

8. It appears that the muscle does not gain in strength beyond one stimulus on the same day. Compared with results obtained from once-a-day program, the strength gain was about eighty per cent when training sessions were held only each second day; with two sessions per week, the increase was about sixty per cent; and when training sessions were held once a week, only forty per cent of the strength gain was realized. One training stimulus every fourteen days produced no change at all in muscle strength.

9. The average in strength increase per week was found to be 1.79 per cent with a standard deviation of $\pm$ 1.20 per cent. About ten per cent of all subjects were effected only slightly during these training periods; about twelve per cent showed very good trainability. These subjects evidenced strength gains of more than three per cent per week.

10. Muscle groups in individuals increase in strength at various

rates. Those muscles that are most used in daily living do not gain as much as do those muscle groups that are less frequently used.

11. Muscle groups that are in an atrophied state may show a gain in strength of five to six times as great as does an untrained normal muscle group in a condition of normal strength.
12. The individual reacts in a unique manner to different training sessions.
13. The nervous system seems to be a paramount factor in trainability.
14. Artificial ultraviolet radiation in the winter months promotes a rate of increase in muscle strength comparable to that observed in the summer months.
15. Women were less responsive to training than men. Age decreases trainability, and the ideal or maximum trainability was found to occur between the ages of twenty and thirty.

Lorback[10] showed statistically significant increases in strength by a single contraction held for six seconds at two-thirds maximum three times a week. This study was done over an eight-week period of training.

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[10]Melvin M. Lorback, "A Study Comparing the Effectiveness of Short Periods of Static Contraction to Standard Weight Training Procedures in the Development of Strength and Muscle Girth" (unpublished M.S. thesis, Pennsylvania State University, June, 1955), p. 68.

Walters, et al.[11] concluded that an attempted full isometric contraction was found to be more effective than the two-thirds maximum method.

Perkins and Kaiser[12] used six second maximum isometric exercises to three muscle groups three times weekly with older people (twenty subjects, age range 62-84, mean 73.6) and found that the subjects showed a gain of approximately fifty per cent in resistance at the time of plateau.

Clarke[13] undertook a study to determine the rate and pattern of fatigue and recovery for both static and dynamic exercises.

With thirty university students, Clarke used a California spring-loaded ergograph to record performance. The students were placed in two groups. One group performed dynamic work for a six-minute period during which the subjects maximally contracted and released the hand gripping muscles once every two seconds. Every thirty seconds a strength reading was recorded. The second group performed static work which consisted of a single contraction held maximally for two minutes. Strength recordings were taken every five seconds.

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[11]C. E. Walters, et al., "Effect of Short Bouts of Isometric and Isotonic Contractions on Muscular Strength and Endurance," American Journal of Physical Medicine, XXXIX (August, 1960), 131-141.

[12]Lois C. Perkins, Helen L. Kaiser, "Results of Short Term Isotonic and Isometric Exercise Programs in Persons Over Sixty," The Physical Therapy Review, XLI (September, 1961), 633-635.

[13]David H. Clarke, "Strength Recovery from Static and Dynamic Muscular Fatigue," Research Quarterly, XXXIII (October, 1962), 349.

At the conclusion of each exercise session, the subject was immediately given a maximum strength test, followed by another test every sixty seconds for ten minutes. This procedure was repeated using the same subject one week later.

It was found in this study that recovery is much faster in the case of static fatigue.

Two groups of ten subjects were used in a study to determine the relative strength gains resulting from isometric and isotonic training programs. Dennison and others[14] placed one group in a weight training program and the second group performed the thirteen exercises of the Commander Set; both groups met twice a week for eight weeks. Each group exhibited significant improvements in chinning and dipping ability which improved arm strength. No significant difference was found between the improvements in mean scores of the two groups.

In a study done to determine the effects of isometric and isotonic exercises on the elbow flexor and spine extensor groups, Adamson[15] concluded that after a four-week training period, the isometric group gain was slightly greater than the isotonic group gain. The difference between the two groups after eight weeks of training was the same as before the experiment was started.

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[14]D. D. Dennison, et al., "Effect of Isometric and Isotonic Exercise Programs upon Muscular Endurance," Research Quarterly, XXXII (October, 1961), 348-352.

[15]G. T. Adamson, "Effects of Isometric and Isotonic Exercises on Elbow Flexor and Spine Extensor Muscle Groups," Health and Fitness in the Modern World (Chicago: Athletic Institute, 1961).

Mathews and Kruse[16] experimented with one hundred and twenty male college students. Groups of students exercised two, three, four, and five times a week using isometric and isotonic exercises. It was found that the isometric exercises caused a greater number of subjects to gain significantly in strength than did isotonic exercises. It was also found that a five-day-a-week program was more beneficial in development of strength than the two and three-day-a-week programs.

In a unique study using two hundred and forty subjects, Alost[17] found no significant difference between an isometric exercise program and a running program. It was also concluded that improvements in cardiovascular condition increased as the frequency of practice periods was increased and that strength and running performance are directly related to frequency of practice periods.

II. STUDIES RELATED TO ISOMETRIC PROGRAMS AND MOVEMENT

In a ten-week isometric training program, Meadows[18] used

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[16]Donald K. Mathews and Robert Kruse, "Effects of Isometric and Isotonic Exercises on Elbow Flexor Muscle Groups," Research Quarterly, XXVIII (March, 1957), 26-37.

[17]Robert A. Alost, "A Study of the Effect of Initial Cardiovascular Condition, Type of Training Program and Frequency of Practice Periods Upon the Cardiovascular Development of College Men" (Doctoral dissertation, Louisiana State University, Baton Rouge, 1963).

[18]Paul Eugene Meadows, "The Effect of Isotonic and Isometric Muscle Contraction Training on Speed, Force, and Strength" (microcarded Ph.D. dissertation, University of Illinois, Urbana, 1959), p. 95.

football players to determine the effects of isotonic and isometric muscle contractions. His study was done on a three-day-per-week training basis and concerned itself with the speed of the offensive football charge, the force of the football charge, chins, dips, vertical jump, leg lift and back lift. Both isotonic and isometric groups were found to bring about significant improvement.

Masley and others[19] concluded that a six-week program of weight training increased speed and coordination more than a like period of time engaged in volleyball or inactivity. It was concluded that strength gain is associated directly with improvement in muscular coordination and speed of movement. Galvin[20] also substantiated this hypothesis with his findings after making a study in which he employed male subjects ranging in age from fourteen to eighteen years of age. Galvin investigated the influence of a weight program on motor coordination, speed of movement, accuracy and dexterity. He concluded that progressive resistance exercises significantly increased the speed of movement of the group used in the study.

In an early investigation that concerned itself with strength gain and speed of muscular contraction, Zorbas and Karpovich[21] used

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[19]John W. Masley and others, "Weight Training in Relation to Strength, Speed, and Coordination," Research Quarterly, XXIV (October, 1953), 308-315.

[20]Sidney Galvin, "An Analysis of the Effects of Progressive Heavy Resistance Exercise on the Motor Coordination of a Group of High School Boys, Ages Fourteen to Eighteen" (microcarded Doctoral dissertation, University of Maryland, College Park, 1958), 96 pp.

[21]William S. Zorbas and Peter V. Karpovich, "The Effect of Weight Lifting Upon the Speed of Muscular Contraction," Research Quarterly, XXII (May, 1951), 145-148.

one group of men in a weight training program and a control group. These two researchers concluded that the experimental group was the fastest in rotary motions of the arm.

Wilkin[22] attempted to determine what effect heavy exercises of a resistant nature would have on speed of movement. He found that a weight training program did not inhibit speed of arm movements. It was also found that a weight training program did not increase speed of movement any more than a like period of training in swimming or golf.

Endres[23] sought to determine the influences of weight training on speed of elbow flexion and extension. He found no detrimental effects; on the contrary, it was found that increases in speed of movement due to weight training were accompanied by marked increases in strength.

III. STUDIES RELATED TO THE EFFECT OF ISOMETRIC EXERCISES AND ENDURANCE

The available literature that supports the hypothesis that programs of isometric training may cause changes in muscular endurance is gradually increasing.

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[22]Bruce H. Wilkin, "The Effect of Weight Training on Speed of Movement," Research Quarterly, XXIII (October, 1952), 361-369.

[23]John Paul Endres, "The Effect of Weight Training Exercise Upon the Speed of Muscular Movement" (microcarded Master's thesis, University of Wisconsin, Madison, 1953), 30 pp.

Walters, et al.[24] concluded that there is a tendency for the preferred and non-preferred hand to gain in endurance in all methods of isometric training programs that were used in the study. Maximal isometric exercises and two-thirds maximal isometric exercises were studied.

Training subjects five time a week for eight weeks, Stoboy and Friedebold[25] found that one ten-second maximum isometric exercise daily promoted endurance. This study employed measurement that was timed to exhaustion.

Baer, et al.[26] assigned sixty-three subjects to both isotonic and isometric exercises which involved the wrist flexors. It was found that increases in endurance were gained by both programs of training.

Swegan[27] found that isometric exercises brought about muscular endurance significant at the .05 level of confidence. Swegan concluded

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[24]Walter, et al., op. cit., XXXIX, 141.

[25]Nussagen H. Stoboy and G. Friedebold, "Behavior of Motor Unit Under Isometric Training," Int. Z. Angeir Physiol., XVII (1959), 391-399.

[26]Adrian D. Baer, Jerome W. Gersten, Barbara M. Robertson, Harold Dinken, "Effect of Various Exercise Programs on Isometric Tension, Endurance and Reaction Time in Humans," Archives of Physical Medicine and Rehabilitation, XXXVI (August, 1955), 495-503.

[27]Donald Bruce Swegan, "The Comparison of Static Contraction with Standard Weight Training in Effect on Certain Movements and Endurance" (Doctoral dissertation, Pennsylvania State University, 1957), p. 152.

that isometric exercises were more effective for developing endurance in knee extension than the conventional method of deep knee bends.

Using isotonic exercises and two programs of isometric exercises (a single contraction a day and twenty contractions a day held for six seconds, four days a week for twelve weeks), Asa[28] found that the repetitive isometric group gained a significantly higher degree of endurance than a single isometric exercise group. There was no significant difference between the isotonic groups in the development of endurance.

Lawrence[29] discovered that the endurance component of the quadriceps muscle realized significant gains as a result of isometric exercises.

Howell and others[30] equated three groups of eleven subjects on the basis of bicycling for two minutes at fourteen kg. resistance. Group One did weight training, Group Two did isometric exercises, and Group Three participated in normal activities. After eight weeks, it was concluded that the experimental groups showed statistically significant improvement over Group Three. There was no significant

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[28]Maxim M. Asa, "The Effects of Isometric and Isotonic Exercises on the Strength of Skeletal Muscle" (microcarded Doctoral dissertation, Springfield College, 1959), p. 142.

[29]Mary S. Lawrence, "Strengthening the Quadriceps: Progressively Prolonged Isometric Tension Method," Physical Therapy Review, XXXVII (October, 1956), 658-661.

[30]Maxwell L. Howell and others, "Effect of Isometric and Isotonic Exercise Programs Upon Muscular Endurance," Research Quarterly, XXXIII (December, 1962), 536-540.

difference between the means of the differences between the initial and final scores of the two experimental groups. It was also concluded, however, that increases in muscular endurance may be effected by certain programs of isometric exercises as well as isotonic exercises.

IV. SUMMARY OF RELATED STUDIES

It seems to be apparent that isometric exercises, when properly executed, promote strength gain in the human being.[31] The by-products of strength with relation to physical performance, in some instances, point up positive results. The amount of strength needed to delay fatigue is not wholly known and the interdependence of the body systems presents a complex problem. That strength is important in physical performance cannot be denied. That strength of an abundant nature is a detriment has been disproven.[32] Studies concerned with isometric exercises and speed[33] indicate that positive gains are realized. That endurance may be gained through isometric exercises has been found to be true as a result of eight studies.[34]

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[31] Supra, Rarick and Larsen, Wolbers and Sills, Taylor, Barham, Hettinger, Mueller, Steinhaus, Lorback, Walters, Perkins and Kaiser, Clarke, Dennison, Adamson, Mathews and Kruse, and Alost.

[32] Supra, Wilkin, Endres, Galvin, Masley.

[33] Supra, Meadows, Masley, Galvin, Zorbas and Karpovich, and Endres.

[34] Supra, Walters, Stoboy, et al., Baer, Swegan, Asa, Lawrence, Howell, and Dennison.

CHAPTER III

PROCEDURE OF THE STUDY

The subjects used in this study were placed in four groups in order to determine the effects of isometric exercises on throwing for distance and continuing to throw for distance. One group performed isometric exercises only; a second group performed isometric exercises and practiced throwing a softball underhand for maximum distance; a third group engaged in throwing a softball underhand for maximum distance; and a fourth group served as a control group.

Prior to and after a six-week training program, all subjects were given tests on arm strength, leg strength, and also a test to determine each subject's ability to throw for distance.

I. SUBJECTS

Eighty college men were used in this study.[1] The subjects volunteered for the study after an introductory invitation during registration week prior to the first week of the fall term at Illinois State University, Normal. The subjects were invited to participate and were accepted only after an understanding was reached regarding attendance, honesty, cooperation and all-out effort throughout the

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[1]Three subjects were eliminated at random from the study so that equal numbers in all groups might be used.

study. All subjects were non-physical education majors or minors and agreed to refrain from any strength development programs and outside physical activities aside from the activities during the class meetings. The eighty subjects were obtained from three physical education service classes. The class activities in which the students were engaged were soccer, archery, and tennis. Class periods for all three classes were fifty minutes in duration and met three times per week. To provide for the possibility that strength in individuals might be attained more from participation in one activity than in another, subjects were placed in each of four groups as follows:

Group A. Seven subjects were chosen from the soccer class, seven subjects were chosen from the archery class, and six subjects were chosen from the tennis class.

Group B. Six subjects were chosen from the soccer class, seven subjects were chosen from the archery class, and seven subjects were chosen from the tennis class.

Group C. Seven subjects were chosen from the soccer class, six subjects were chosen from the archery class, and seven subjects were chosen from the tennis class.

Group D. Six subjects were chosen from the soccer class, seven subjects were chosen from the archery class, and seven subjects were chosen from the tennis class.

The placement of each subject in a training program group was done prior to the initial testing program. Since two groups were to be engaged in a throwing program, an attempt was made to include

those subjects for the throwing groups who did not have either a class prior to or after the activity class in which the subjects were engaged. This was attempted because of the time needed in the practice throwing aspect of the training program. With this in mind, the subjects were assigned to the following groups:

Group A. The subjects in Group A participated in the isometric exercise program. This program consisted of three arm exercises done with the dominant arm and one leg exercise done with each leg. This was done in addition to the class activity of soccer, archery, or tennis, depending upon the student's class assignment.

Group B. The subjects in this group participated in the isometric exercise program and a softball throw for distance program. The isometric exercise program was identical to that of Group A. The softball practice period consisted of paired subjects practicing throwing a regulation softball for maximum distance eighty times each class meeting.

Group C. The subjects in Group C participated in a softball throw for maximum distance each period the class met. This throwing program was identical to that of Group B. The subjects also participated in their regular physical education activity class.

Group D. The subjects in Group D served as a control group. These subjects did participate in the activity for which they

were enrolled but did not engage in either the isometric exercise program or the softball throw for maximum distance program.

II. TESTING EQUIPMENT

Cable Tensiometer. This piece of equipment was originally designed for aircraft cable tension specifications. The Cable Tensiometer records tension through a range of ten to two hundred pounds. This tensiometer was the C-8 type and was produced by the Wac Engineering Company at Dayton, Ohio.

Isometric Exercise Belt. Throughout the training program, ten isometric exercise belts were provided. These belts consisted of a continuous belt webbing one inch wide and forty-eight inches in length. A two inch by four and three-quarter inch piece of wood was secured to the webbing so that the instep of the foot might be inserted.

Isometric Testing Belt for Leg Strength. A length of belt webbing was removed from an isometric belt, and an equal length of one-sixteenth inch airplane cable was substituted in its place. This provided for a standard length used for the training and testing of subjects. The one-sixteenth inch airplane cable attached to the isometric training belt made it possible to determine the tension exerted by the subjects.

Isometric Testing Belt for Arm Strength. An eighteen inch length of one-sixteenth inch airplane cable was secured to an eighteen

inch length of welded chain at one end and a web belt at the other end.

The apparatus used for the leg and arm strength tests is shown in Figure 1, page 26.

III. STRENGTH TESTING PROCEDURE

Since two groups used isometric exercises in this study and two groups did not, it was felt that all four groups should be tested for strength. The strength-testing results of the isometric exercise groups would therefore determine whether strength gain was realized as a result of the isometric exercises. Although no exercises were done by the other two groups, strength tests were taken. It was felt that should strength gains be found in the latter two groups, less importance should be placed on the results of strength attainment of the four groups involved.

The Aircraft Cable Tensiometer was used to test both leg and arm strength. Since the Aircraft Cable Tensiometer gauge has an arrestor on the needle, accurate readings were easy to obtain.

Arm Strength Test. For this test of strength, the subject was requested to assume a position approximating an underhand softball throw. The subject inserted his hand into the web harness and a loop snubber was slipped down the harness webbing to secure the subject's wrist in the harness.[2] The subject was placed in a position with his

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[2]H. Harrison Clarke, Cable-Tension Strength Tests (Chicopee, Massachusetts: Brown-Murphy Co., 1953), pp. 1-4.

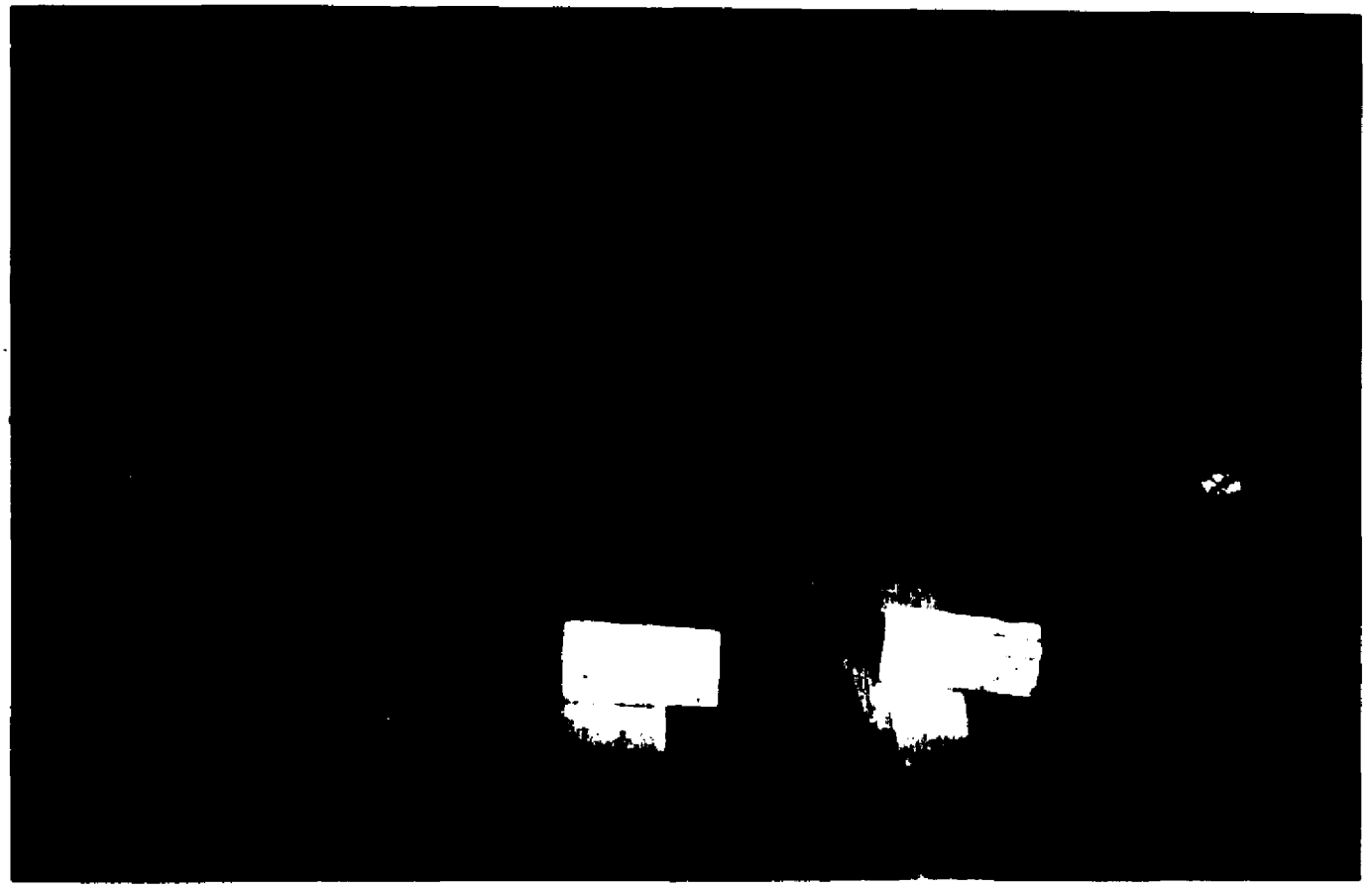

Figure 1. Testing apparatus used for isometric testing and isometric exercises. From left to right: arm strength apparatus, leg strength apparatus, isometric training belt and Aircraft Cable Tensiometer.

dominant arm parallel to the floor, or in a position approximating that of a person starting the downward swing of the arm in executing an underhand softball throw. The section of chain links was used to adjust the testing strap for the variance in height of the subjects. Once the subject was in the proper position for testing, the number of the chain link used in the adjustment was recorded for future reference so that a standardized position might be duplicated for subsequent tests throughout the training program.

The arm strength tests were administered in the physical education fieldhouse at Illinois State University. The site was at the base of an "I" beam. Each subject was given the following instructions: "You are to pretend you are going to throw a ball underhand as far across the fieldhouse as possible. Your arm is arrested and you must exert with your fist against the "I" beam. Do not bend your elbow or 'curl' your wrist."

The subject was given two trials for the arm strength test, and the greater reading of the two was recorded.

The measuring device used to determine the strength score was a cable tensiometer and the readings taken from the gauge were in pounds. Once the subject was considered to be in the proper position, the tester gave the subject a verbal command to execute the downward stress. The cable tensiometer was clamped onto the cable of the harness and at maximum execution, the tester set the "lock" on the reading gauge. The "lock" set on the cable tensiometer enabled the tester to obtain an exact reading.

The procedure used in testing arm strength is shown in Figure 2, page 29.

Leg Strength Test. Using an isometric belt with a section cut out and replaced by one-sixteenth inch airplane cable, the subjects were tested for leg strength.[3] The belt was placed under the subject's instep of the dominant leg and over the leg in a bent position. The isometric belt was placed as far up into the area of the groin as possible so that each subject would have a standard position in which to be tested and so that the subject doing isometric exercises in the training program would be able to duplicate the position of the leg.

The subject with the isometric cable belt in place and sitting on a chair was instructed to execute a maximum attempt to extend the leg upon command. The subject was instructed to grasp the under side of the chair with both hands for the purpose of stability.

The procedure used to test leg strength is shown in Figure 3, page 30.

Throw for Distance Test. This test was administered in a fieldhouse on the campus at Illinois State University. Two stations were used allowing two subjects to be tested at a time. Since the entire eighty subjects were given this test prior to and at the conclusion of the training program, an expeditious procedure was needed.

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[3]Initial and final strength scores are shown in Appendixes I, J, K, L.

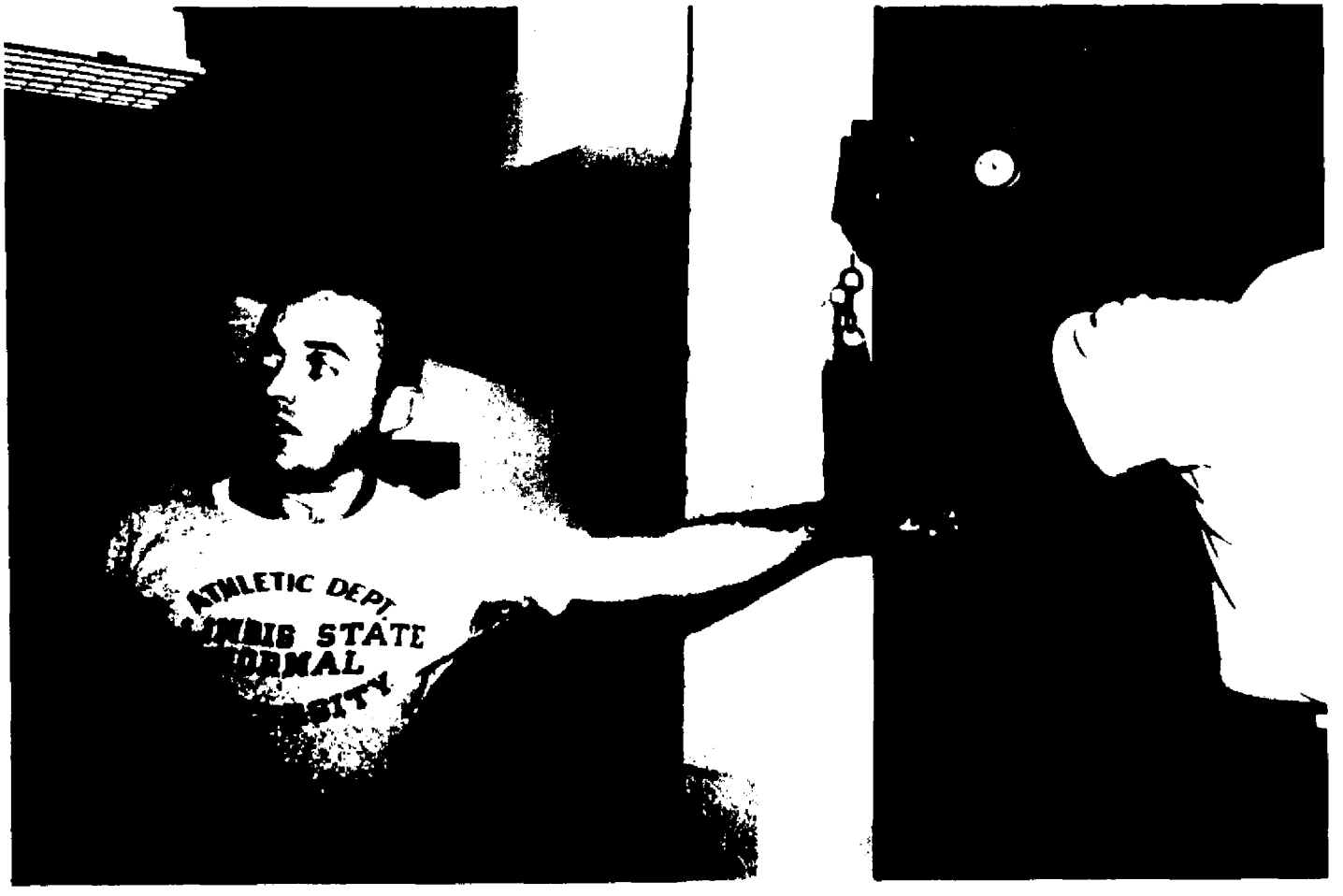

Figure 2. Testing apparatus and position of subject for measurement of arm strength.

Figure 3. Testing apparatus and position of subject for measurement of leg strength.

A station consisted of the following items:

1. Pitching Rubber. A twenty-four by six inch one-quarter inch plywood board secured to a black top surface was used.

2. Softballs. Ninety regulation twelve inch softballs were used. The softballs were caught after they had bounced once on the black-top surface and were placed in containers. Periodically, the balls were returned to the throwing stations. Subjects other than the two being tested at the moment served as retrievers.

3. Timing Device. Since the subjects threw eighty times for distance at six-second intervals, one member of the testing team sat beside the subject and instructed him to throw on time from readings taken from a stop watch.

4. Height Standard. Since maximum distance is attained when throwing ball type objects at approximately a forty-five degree angle,[4] a rope was stretched across the path of the throwing station twelve feet from the pitching rubber. The rope was stretched at a height of nine and one-half feet so that some allowance for human error might be made in duplicating exactly an angle of forty-five degrees.

5. Floor Markings for Distance. A two inch wide white tape marked off at intervals of one foot up to one hundred seventy-five feet was placed lengthwise on the fieldhouse floor. Ninety degree

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[4]John W. Bunn, Scientific Principles of Coaching (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1962), p. 147.

lines were drawn from this strip of tape and distances were numbered at the extreme sides of the throwing area in graduations of five feet in chalk on the fieldhouse floor. No difficulty whatsoever was experienced in determining the distances of the thrown softballs. Distances were recorded to the nearest foot.

6. Administration of Softball Throw. Prior to taking the softball throw for distance, each subject was given the following instructions:

> You are to throw underhand eighty times for maximum distance. The timer will verbally inform you when to throw. After each throw you will reach to the basket beside your pitching rubber and pick up another ball; the timer will say 'Get ready' at the fifth second and order you to throw at the arrival of the sixth second.
>
> The rope stretched across the front of the pitching rubber is a guide. If you throw just over the rope, your throw will approximate a forty-five degree angle which will give maximum distance. If you let go of the ball too soon, the thrown ball will go straight out on a line; if you hold on to the ball too long, the thrown ball will go straight up. Make every effort to just clear the rope. If the ball slips out of the hand during any trial, that trial will not be recorded and a substitute trial will be allowed.
>
> You will stand on the pitching rubber with both feet facing the direction you are to throw. You will hold the ball in both hands just below the waist. Upon the command of the timer, you will take one 'stride step' and one complete 'arm swing' and throw the ball. You will throw eighty consecutive times, one throw every six seconds. Throw for maximum distance from the first throw. Do not pace yourself. Try to throw down the floor over the white tape. Again, do not pace yourself.

IV. ISOMETRIC EXERCISE PROGRAM

Five functional isometric exercises were practiced by all subjects in two groups. These subjects performed one leg exercise

on both legs and three arm exercises on the dominant arm. The exercises were performed for ten-second durations and with an attempt toward maximum effort. These exercises were done three days a week for a period of six weeks. Isometric belts made of webbing and attached wooden blocks were employed for the exercises. The subjects assisted one another in executing the arm exercises. The leg exercises were done independently. The subjects performed the exercises at the conclusion of class participation in their regular activity classes. The strength in pounds exerted by each subject was recorded once weekly throughout the six-week training period. For purposes of motivation, these subjects were informed of their individual progress in strength gain.

The three arm isometric exercises were done in three positions. The first exercise was done with the subjects approximating that position of the softball throw which would position the arm in a position parallel to the floor; that is, the arm was arrested at that position where the down-swing of the arm was parallel to the floor or at a ninety degree angle to the subject's body.

The second isometric exercise administered was with the subject's arm in a forty-five degree angle with the floor. The third position used was at a ninety degree angle with the floor or just prior to the position where the subject would release the softball when throwing.

The three isometric arm exercises are shown in Figures 4, 5, and 6, pages 34, 35, and 36.

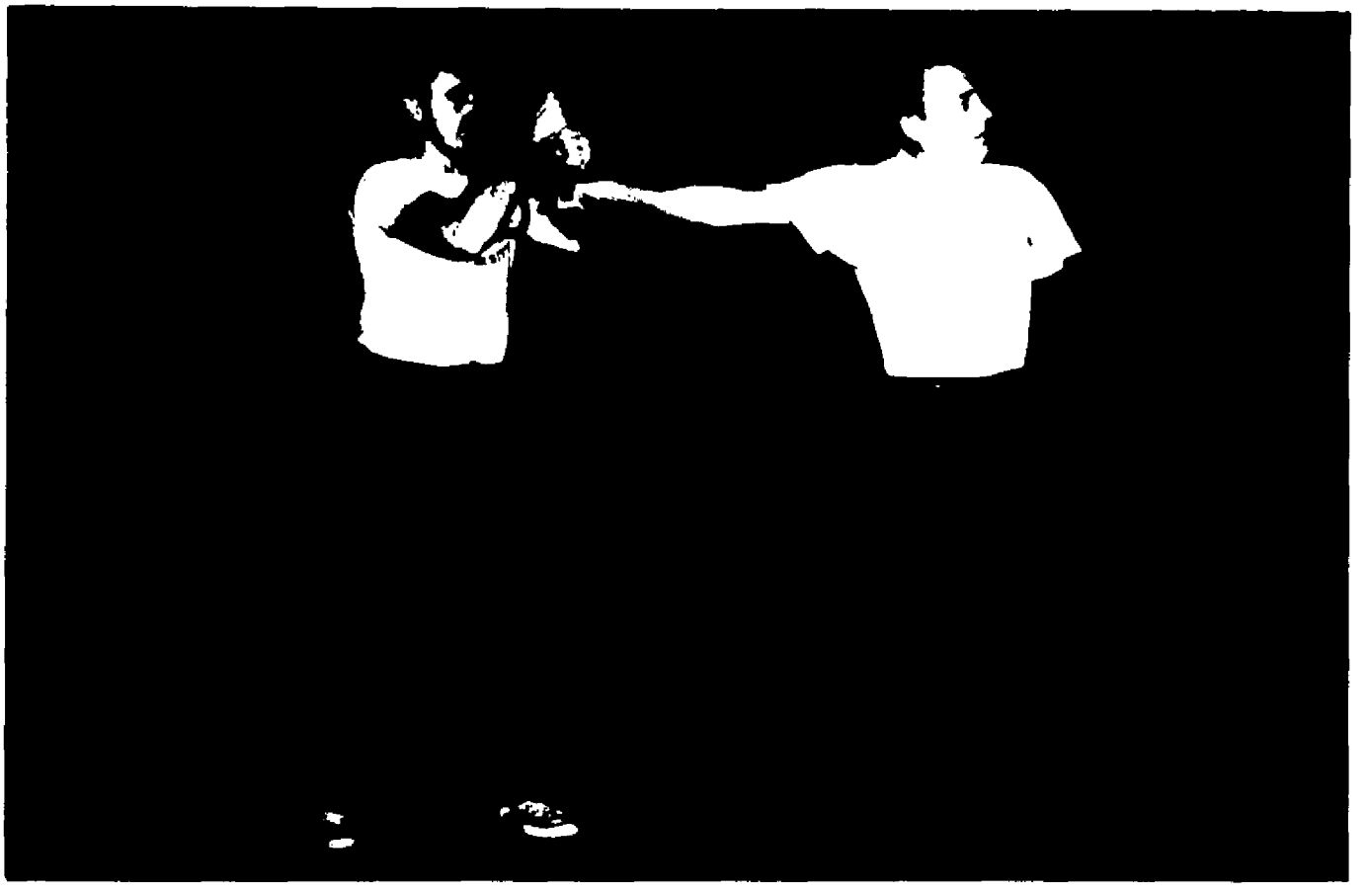

Figure 4. Procedure and position of subject in first isometric arm exercise.

Figure 5. Procedure and position of subject in second isometric arm exercise.

Figure 6. Procedure and position of subject in third isometric arm exercise.

The isometric leg exercises were practiced on both legs and were done with an isometric exercise belt identical in size to the belt used to measure leg strength. See Figures 1 and 3, pages 26 and 30.

CHAPTER IV

PRESENTATION AND ANALYSIS OF DATA

The data obtained in this study dealing with the effects of four groups and their ability to throw for distance and to continue to throw for distance were analyzed statistically by means of analysis of variance. A Type III design was employed as described by Lindquist.[1] Since the pre-test data showed no significant effects by interaction, only the results of the post-test were used. The results of the pre-test and post-test are presented in Table I, page 39, and Table II, page 40. The initial and final means are presented in Appendixes A, B, C, and D.

I. ANALYSIS OF THROW FOR DISTANCE DATA

Only the post-test data were used. The only significant difference found in the pre-test was in the means of the total trials of all subjects. This can be interpreted as having occurred by chance or possibly having been due to the different reactions of individual subjects under the stress of throwing eighty times for distance. There were differences from throw to throw for all subjects and between groups, but the differences were of the same order for all four

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[1]E. F. Lindquist, Design and Analysis of Experiments in Psychology and Education (Cambridge, Massachusetts: The Riverside Press, Houghton-Mifflin Company, 1953), pp. 281-284.

TABLE 1

ANALYSIS OF VARIANCE FOR PRE-TEST OF COLLEGE STUDENTS' ABILITY TO THROW A SOFTBALL FOR DISTANCE

Source of variation	df	Sums of squares	Mean squares	"F" ratio
Total	79	56686.7187	717.5534	--
1) Exercise group compared with no-exercise group	1	1098.8438	1098.8438	1.53
2) Throw group compared with no-throw group	1	108.3125	108.3125	0.15
3) Interaction of 1 and 2	1	721.2188	721.2188	1.00
4) Error	76	54758.3438	720.5045	—
5) Total	240	3449.8438	14.3743	--
6) All groups by trials	3	289.7500	96.5833	7.33*
7) Interaction of 1 and 6	3	79.6258	26.5417	2.01
8) Interaction of 2 and 6	3	48.0625	16.0208	1.22
9) Triple action of 1, 2, & 6	3	26.1250	8.7083	0.66
10) Error	228	3006.2813	13.1854	—
11) Total	319	60136.5625	188.5159	—

*indicates significance at the .01 level

TABLE II

ANALYSIS OF VARIANCE FOR POST-TEST OF COLLEGE STUDENTS' ABILITY TO THROW A SOFTBALL FOR DISTANCE

Source of variation	df	Sums of squares	Mean squares	"F" ratio
Total	79	61909.0000	783.6582	—
1) Exercise group compared with no-exercise group	1	2704.5625	2704.5625	3.93***
2) Throw group compared with no-throw group	1	6871.8750	6871.8750	9.98*
3) Interaction of 1 and 2	1	16.2813	16.2813	0.02
4) Error	76	52316.2813	688.3721	—
5) Total	240	2287.4375	9.5310	—
6) Comparison of all groups by trials	3	216.3438	72.1146	8.61*
7) Interaction of 1 and 6	3	95.9375	31.9792	3.82**
8) Interaction of 2 and 6	3	8.5938	2.8646	0.34
9) Triple action of 1, 2, & 6	3	57.7813	19.2604	2.30
10) Error	228	1908.7813	8.3718	—
11) Total	319	64196.4375	201.2428	—

*indicates significance at the .01 level
**indicates significance at the .05 level
***indicates significance at the .10 level

groups. The fact that the interactions of the pre-test data revealed no significant differences permits the use of only the post-test data.

Starting with the highest order of interaction (see Table II, page 40) it was found that no significant differences existed between the exercise groups, the no-exercise group, and all groups by trials. This triple interaction produced an "F" ratio of 2.306. This ratio is not significant at the .05 level.

In order to determine the effects of an isometric exercise program upon the ability to throw a softball for maximum distance, the two groups which included isometric exercises in their training program were combined and referred to as the exercise group. This group was compared to the two groups that were combined to form the no-exercise group. As shown in Table V, page 45, the exercise group exceeded the mean throw of the no-exercise group by 6.23 feet. Although this appears to be a rather large difference, the "F" ratio for this comparison was 3.93, which is not quite significant at the .05 level.

The two groups which practiced throwing during the training period experienced gains which resulted in a significant difference when compared to the two groups which did not have throwing practice included in their training program. An "F" ratio of 9.98 is significant beyond the .01 level. This comparison indicates that the throw groups performed better than the no-throw groups regardless of exercise condition or trial condition since there were no significant interactions of the throw variables with exercise or trials.

The interaction of the exercise groups versus no-exercise groups

and the throw groups versus no-throw groups failed to produce a significant difference. An "F" ratio of 0.0237 indicates a negligible difference.

An analysis of differences between all groups and blocks of twenty trials, disregarding isometric exercise and throwing groups, proved to be significant at the .01 level of significance as indicated by an "F" ratio of 8.6139.

Since a significant difference occurred between trials by groups, it is necessary to investigate more thoroughly the effects of exercise and no exercise on continuing to throw for maximum distance. To determine the effects of isometric exercises on the ability to continue throwing a softball for maximum distance, the scores of the two groups using isometric exercises were combined to form one group called the exercise group. The scores of the two groups not using isometric exercises were combined to form another group. This group was called the no-exercise group.

An analysis of variance between means of the first twenty, the second twenty, the third twenty, and the fourth twenty throws was made for the exercise group and for the no-exercise group. As indicated in Table IV, page 44, the exercise group had a small gradual decline in the means from the first group of twenty throws to the fourth group of twenty throws. The greatest difference between any two groups was the .69 foot difference between the first and fourth groups. As shown in Table III, page 43, the "F" ratio for this difference is too small to be significant at the .10 level. The "F" ratio for the exercise group was .51.

TABLE III

ANALYSIS OF VARIANCE FOR POST-TESTS FOR EXERCISE AND NO-EXERCISE GROUPS' ABILITY TO THROW A SOFTBALL FOR DISTANCE

Test	N	df	Sums of squares	Mean squares	"F" ratio
Exercise	40	3	14.7656	4.9219	0.508
No-exercise	40	3	300.0248	133.3416	15.927*

*indicates significance at the .01 level

Error Term = 8.3718

TABLE IV

FINAL MEANS BY TRIALS OF TWENTY UNDERHAND THROWS FOR COLLEGE MEN AFTER VARIOUS TYPES OF TRAINING PROGRAMS

Group	N	1	2	3	4	Total
Exercise only	20	105.48	106.53	105.78	105.79	105.90
Exercise + throw	20	116.56	115.43	115.59	114.86	115.61
Throw only	20	110.32	111.02	108.99	107.06	109.35
Control	20	102.44	100.59	100.59	98.50	100.53
Exercise	40	111.02	110.98	110.69	110.33	110.76
No-exercise	40	106.38	105.81	104.79	102.78	104.94
Throw	40	113.44	113.23	112.29	110.96	112.48
No-throw	40	103.95	103.56	103.19	102.15	103.22
Total	80	108.70	108.40	107.74	106.56	107.85

TABLE V

DIFFERENCES BETWEEN MEANS OF INITIAL ARM AND LEG STRENGTH SCORES FOR ALL SUBJECTS

Arm Strength						
Group	N	Mean	S D	S. E. Mean	Difference	t
A	20	12.97	5.70	3.25	259.50	9.93*
B	20	12.60	5.61	3.16	252.0	9.79*
C	20	1.85	4.93	.38	37.0	1.64
D	20	-.43	9.35	.707	-8.5	-.20

Leg Strength						
Group	N	Mean	S D	S. E. Mean	Difference	t
A	20	15.40	8.48	4.03	308.0	7.92*
B	20	15.45	8.73	4.07	309.0	7.72*
C	20	6.75	7.53	2.32	135.0	3.91*
D	20	1.23	4.08	.959	24.5	1.31

*significant beyond .01 level of confidence

Group A practiced isometric exercises only.
Group B practiced isometric exercises and throwing a softball for maximum distance.
Group C practiced throwing a softball for maximum distance only.
Group D did not practice isometric exercises or throwing a softball for maximum distance.

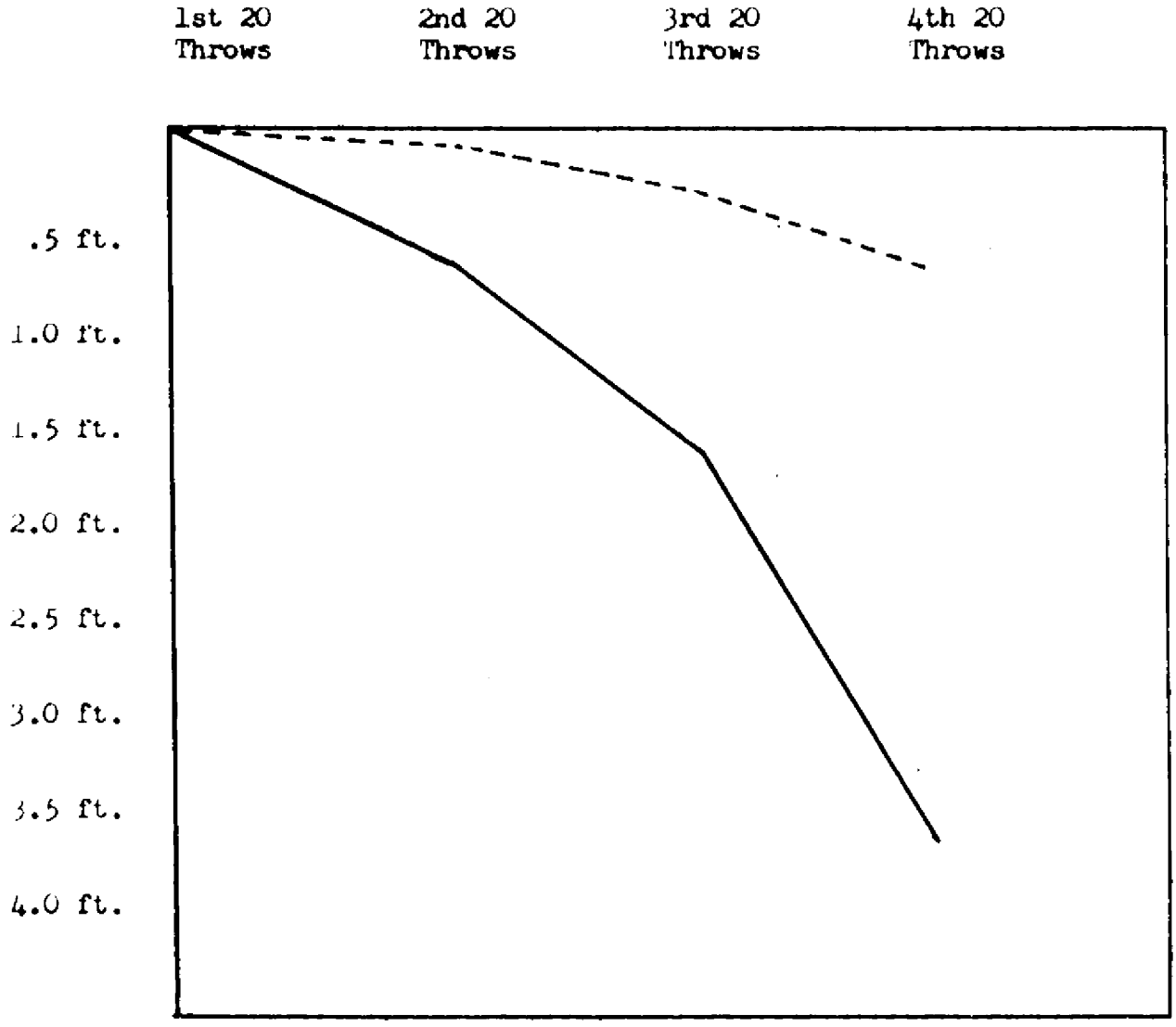
The no-exercise group also had a steady decline from the first twenty throws to the fourth twenty throws. This decline was greater than the decline experienced by the exercise group. As shown in Table IV, page 44, the difference between the first group of throws and the last group of throws was 3.60 feet. The "F" ratio for the variation between the means in the no-exercise group was significant. This "F" ratio was 15.93, which is significant at the .01 level.

In order to further analyze the effect of isometric exercise on the ability to continue throwing a softball for distance, a regression line was plotted for the exercise group and the no-exercise group. These regression lines are shown in Chart 1, page 47. This chart graphically illustrates the rather gradual decline of the exercise group and the marked decline of the no-exercise group. Although this decline for the exercise group was consistent, it was not large enough to be significant. The decline for the no-exercise group was large enough to be significant.

The "F" ratio for the regression for the no-exercise group was calculated and found to be significant at the .01 level of significance. In order to determine whether this regression was linear, quadratic, or cubic, the "F" ratio was determined for this deviation; and, as shown in Table III, page 43, it was found to be significant. The linear deviation sum of squares was then subtracted from the treatment sum of squares, and the remaining deviation was not significant. This indicated that the decline in ability to

CHART I

REGRESSION PLOT FOR MEAN DISTANCE OF SOFTBALL THROWS FOR DISTANCE BY COLLEGE MEN WHO EXERCISED DURING TRAINING PERIOD AND THOSE WHO DID NOT EXERCISE DURING TRAINING PERIOD



N = 40

Exercise - - - - - - - - - -

No-Exercise _____

continue to throw a softball for distance by the no-exercise group was linear in nature.[2]

The interaction of the throw in training groups versus the trial analysis was not significant as indicated by an "F" ratio of 0.34.

II. ANALYSIS OF STRENGTH TEST SCORES

Although only two groups practiced isometric exercises during the training period, all four groups were measured prior to and at the conclusion of the prescribed period. Both leg and arm strength scores were obtained for every subject participating in the study. A comparison of means was utilized to determine whether significant strength gains were realized by both groups which practiced isometric exercises. One group of twenty subjects practicing isometric exercises only during the training period registered "t" scores of 9.93 and 7.92 for arm and leg strength, respectively. Another group of twenty subjects practicing isometric exercises and throwing throughout the training period registered "t" scores of 9.79 and 7.72. All of the "t's" were significant at the .01 level. The two groups of twenty subjects which did not practice isometric exercises did not gain in strength in arm tests, however, one group gained in leg strength as indicated by the "t" of 3.91. This increase may be

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[2]Ronald A. Fisher and Frank Yates, Statistical Tables (New York: Hafner Publishing Company, Inc., 1953), pp. 22, 80.

attributed to the strain put on the leg muscle and during the throwing process. (See Table V)

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

I. SUMMARY

It was the purpose of this study to determine the effects of isometric exercises on throwing a softball for maximum distance and also on the ability to sustain this maximum distance.

Eighty male students at Illinois State University at Normal, Illinois served as subjects. One group practiced three functional isometric exercises at positions within the range of motion of a softball throw. These subjects also practiced one isometric exercise on each leg which approximated the stride execution of the softball throw. The five exercises were practiced three times a week with each exercise lasting ten seconds in duration. Maximum effort was attempted at each practice period. Another group did the same isometric exercises as the group mentioned above in addition to practicing throwing a softball for distance eighty times, three times a week. Another group practiced throwing a softball for distance eighty times, three times a week but did not include any form of exercise in the training period; and one group served as a control group.

All subjects were tested for their ability to throw a softball for distance as a pre-test. All subjects were also pre-tested for

arm and leg strength at specified positions. At the end of a six-week training period, all subjects were re-tested to determine if significant changes in throwing for distance eighty times as well as differences in leg and arm strength had taken place.

In order that the endurance factor might be investigated, the eighty throws were analyzed in groups of twenty as well as by the total eighty throws.

A Type III design employing analysis of variance was utilized in treating the data so as to determine the effects of the different training programs and the distances each group threw and continued to throw for maximum distance. This analysis was made on the IBM 1620 computer at the Data Processing Center at The State University of Iowa, Iowa City, Iowa. The "t" test of significance was utilized in comparing the differences between the original and final mean scores of arm and leg strength measured for all subjects who took part in the study.

The following findings were obtained in this study:

1. Although the isometric exercise groups performed better than the no-isometric exercise groups, significance was not quite realized at the .05 level.
2. When tested at the conclusion of the training period, the isometric exercise groups maintained ability to throw for maximum distance.
3. The no-exercise groups experienced a significant decline in distance over the eighty throws for distance when tested

at the conclusion of the training period.

4. The subjects who practiced isometric exercises in the training period showed significant gains in strength of the dominant arm and leg.

II. CONCLUSIONS

Within the limitations of this study, the data allow the following conclusions:

1. Functional isometric exercises will improve the ability to maintain the maximum distance thrown.
2. The addition of a functional isometric exercise program to a throwing for distance program will produce positive gains beyond that of a throwing program alone.
3. A program of practice throwing for maximum distance will improve the ability to throw for maximum distance.
4. A program of isometric exercises will bring about significant improvements in strength.
5. Practicing throwing a softball for maximum distance, with isometric exercises, will improve leg strength.

III. RECOMMENDATIONS

In the opinion of the author, the following related areas are in need of further investigation:

1. The effects of isometric exercise programs on speed and endurance.

2. The influence of isometric exercises over a longer training period.
3. The influence of isometric training using subjects who are highly skilled in a specific area of physical activity.
4. The influence of isometric exercise on ballistic type movements.

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APPENDIX

APPENDIX A

INITIAL AND FINAL MEAN SCORES* IN GROUPS OF TWENTY THROWS

FOR COLLEGE MEN WHO PRACTICED ISOMETRIC EXERCISES ONLY

	1st 20		2nd 20		3rd 20		4th 20	
SUBJECTS	'	"	'	"	'	"	'	"
1	104.65	105.75	108.30	105.95	108.85	105.85	99.20	99.65
2	123.00	123.60	122.80	123.60	119.55	123.45	121.20	125.15
3	82.75	98.45	80.95	95.05	78.20	91.05	77.90	86.60
4	97.70	110.05	102.75	114.65	101.70	114.15	102.90	113.55
5	75.85	86.75	73.70	90.70	77.80	87.15	77.80	86.55
6	113.00	106.85	117.55	106.05	117.65	111.10	110.75	109.30
7	100.00	114.35	105.20	112.75	107.75	104.55	108.55	109.55
8	118.60	125.75	122.55	131.40	123.45	135.55	128.90	132.65
9	102.15	109.95	106.70	106.75	106.20	124.05	97.80	121.15
10	103.50	114.40	107.10	115.40	103.40	114.65	103.10	113.50
11	90.45	103.60	95.65	105.55	98.35	107.15	99.75	105.05
12	95.30	98.50	100.50	101.30	105.85	95.20	107.65	98.70
13	75.65	84.90	81.95	85.05	78.70	83.05	81.65	80.70
14	111.20	102.10	110.35	103.35	110.60	100.90	109.25	105.25
15	80.50	96.85	80.40	97.25	83.50	94.15	80.70	96.95
16	100.60	103.15	101.70	103.80	110.50	101.20	103.00	101.55
17	104.15	100.01	101.75	102.40	102.55	98.95	100.65	102.35
18	100.50	111.75	103.50	113.20	98.50	111.60	104.55	113.65
19	93.85	109.05	104.25	108.85	95.05	102.90	88.45	105.50
20	92.40	103.15	91.80	107.00	95.55	108.35	97.90	107.90
TOTAL	1965.80	2109.00	2019.45	2130.05	2023.70	2115.55	2001.65	2115.25
MEAN	98.41	105.45	100.99	106.53	101.21	105.78	100.10	105.79

*Scores are given in feet.

APPENDIX B

INITIAL AND FINAL MEAN SCORES* IN GROUPS OF TWENTY THROWS FOR COLLEGE MEN WHO PRACTICED ISOMETRIC EXERCISES AND ALSO PRACTICED THROWING A SOFTBALL FOR DISTANCE

	1st 20		2nd 20		3rd 20		4th 20	
SUBJECTS	'	"	'	"	'	"	'	"
1	86.45	102.90	91.60	103.65	93.40	101.45	97.00	101.75
2	95.10	106.65	99.95	107.10	100.00	104.75	101.45	102.80
3	96.05	104.05	97.60	103.50	96.25	105.30	95.55	106.50
4	109.65	113.20	108.60	109.20	104.35	108.20	106.20	108.15
5	98.50	109.45	96.65	107.40	101.50	107.30	100.40	106.55
6	101.00	133.80	108.85	134.15	112.45	136.60	117.80	137.90
7	97.35	119.40	97.90	116.50	100.35	122.30	100.05	124.85
8	109.00	122.20	105.30	115.30	112.90	116.35	104.05	115.70
9	99.70	125.30	99.05	114.30	97.80	112.50	95.80	109.30
10	107.60	119.15	100.95	116.35	100.85	114.70	98.50	114.30
11	113.90	132.90	114.75	132.80	113.60	134.95	113.45	134.90
12	87.60	101.95	86.75	103.00	92.10	103.65	90.70	105.05
13	96.20	111.10	101.10	106.80	93.10	107.15	95.20	107.45
14	89.15	111.05	99.85	114.35	104.45	112.50	102.70	110.60
15	107.60	130.80	109.85	130.45	121.50	132.70	115.20	126.35
16	106.00	111.70	106.45	110.20	107.05	106.30	110.50	108.30
17	102.50	111.75	95.70	116.95	107.90	115.90	103.55	117.60
18	98.95	114.20	108.55	114.95	118.40	115.25	114.20	108.25
19	101.40	112.15	104.70	111.90	103.60	113.20	103.80	111.80
20	132.85	137.15	139.40	139.50	143.70	140.45	144.70	138.85
TOTAL	2036.55	2330.85	2073.55	2308.35	2124.25	2311.50	2110.80	2296.95
MEAN	101.85	116.56	103.70	115.43	106.28	115.59	105.56	114.86

*Scores are given in feet.

APPENDIX C

INITIAL AND FINAL MEAN SCORES* IN GROUPS OF TWENTY THROWS FOR COLLEGE MEN WHO PRACTICED THROWING A SOFTBALL FOR DISTANCE

	1st 20		2nd 20		3rd 20		4th 20	
SUBJECTS	'	"	'	"	'	"	'	"
1	103.90	121.00	113.10	126.50	111.35	125.60	104.65	123.55
2	95.55	106.45	95.75	114.70	95.05	109.85	97.35	110.90
3	86.05	105.95	88.20	101.05	84.95	101.20	77.00	97.05
4	122.35	134.30	122.65	133.90	124.55	134.10	129.80	132.55
5	88.10	104.60	91.60	98.60	91.50	97.15	91.40	101.05
6	98.70	101.65	99.45	118.40	95.70	113.40	92.25	114.25
7	69.35	92.45	72.35	91.10	75.95	82.20	72.70	80.75
8	85.70	107.40	86.70	108.00	91.95	105.95	93.90	101.65
9	118.40	138.75	121.05	134.55	122.00	129.45	125.45	125.60
10	103.60	115.05	108.10	116.55	108.60	114.75	104.95	115.45
11	92.75	104.85	91.45	102.45	82.05	101.70	74.75	97.95
12	80.90	99.10	87.30	95.95	90.30	94.40	85.45	88.85
13	104.40	116.90	110.75	118.05	109.05	114.70	115.40	112.15
14	114.90	104.55	116.40	104.25	100.35	101.45	99.40	97.45
15	81.90	108.60	81.55	107.95	84.65	107.05	84.25	102.75
16	109.15	115.95	114.80	112.00	114.10	109.85	110.30	111.70
17	89.40	98.10	92.25	104.15	86.45	104.75	88.95	100.30
18	73.50	91.50	79.05	89.95	88.25	92.35	90.10	89.70
19	96.30	118.80	99.10	118.75	100.25	119.30	98.30	115.05
20	104.85	119.95	103.60	123.05	110.30	120.15	106.35	121.90
TOTAL	1919.75	2205.90	1975.20	2219.90	1967.34	2179.35	1942.70	2140.60
MEAN	96.05	110.32	98.79	111.02	98.40	108.99	97.36	107.06

*Scores are given in feet.

APPENDIX D

INITIAL AND FINAL MEAN SCORES* IN GROUPS OF TWENTY THROWS FOR COLLEGE MEN WHO DID NOT PRACTICE ISOMETRIC EXERCISES OR THROWING A SOFTBALL FOR DISTANCE

	1st 20		2nd 20		3rd 20		4th 20	
SUBJECTS	'	"	'	"	'	"	'	"
1	89.35	92.30	87.30	89.10	91.20	95.15	92.70	89.50
2	91.45	99.95	91.60	98.00	97.40	96.85	95.20	95.10
3	113.05	108.80	114.00	112.30	108.55	115.65	107.85	101.90
4	101.00	100.90	104.00	99.90	102.90	99.00	104.65	96.30
5	126.55	138.35	131.55	135.05	134.00	140.50	134.70	135.45
6	115.30	108.85	116.45	109.60	111.55	107.65	112.60	106.00
7	115.15	128.30	119.45	124.60	113.40	124.95	117.10	121.55
8	78.50	90.60	79.40	90.35	76.75	89.65	78.40	88.75
9	115.95	117.20	115.20	114.05	113.60	113.50	108.40	108.95
10	75.10	86.75	72.75	76.30	71.05	74.25	67.65	72.10
11	103.50	105.15	107.25	105.15	109.70	105.45	103.95	105.20
12	104.20	106.05	103.85	110.40	108.75	105.95	105.10	104.80
13	103.70	100.70	108.80	104.15	105.00	101.80	102.60	103.30
14	81.90	75.05	79.45	70.00	80.35	65.25	80.35	68.70
15	88.05	95.20	85.65	91.10	81.05	96.60	90.90	96.90
16	111.70	124.75	112.35	119.35	112.95	117.90	107.70	116.25
17	87.25	88.40	87.50	86.05	87.60	82.80	88.90	81.65
18	100.70	101.60	108.80	98.90	104.35	99.85	103.50	99.30
19	89.55	100.85	96.80	103.30	97.50	103.90	98.45	102.55
20	89.55	78.55	81.35	74.00	81.95	74.55	81.00	75.45
TOTAL	1981.50	2048.30	2003.50	2011.65	1989.60	2011.22	1981.70	1969.70
MEAN	99.10	102.44	100.20	100.59	99.51	100.59	99.10	98.50

*Scores are given in feet.

APPENDIX E

INITIAL AND FINAL RAW SCORES* OF ARM STRENGTH AND COMPUTATIONS FOR SIGNIFICANCE FOR COLLEGE MEN WHO PRACTICED ISOMETRIC EXERCISES

SUBJECTS	Pre-test	Post-test	Difference	Difference^2
1	30	47	17	289
2	37.5	51	13.5	182.25
3	36	45	9	81
4	24	40	16	256
5	26	46	20	400
6	34	64	30	900
7	25	44	19	361
8	30	46	16	256
9	46	56	10	100
10	37.5	42	4.5	20.25
11	24	35	11	121
12	24	35	11	121
13	20	28	8	64
14	31.5	40	8.5	72.25
15	37	55	18	324
16	40	48	8	64
17	27.5	38	10.5	110.25
18	27.5	38	10.5	110.25
19	32	42	10	100
20	26	35	9	81
			$\Sigma D = 259.5$	$\Sigma D^2 = 4013.25$

*Scores are given in pounds.

APPENDIX E (continued)

$$t = \frac{\bar{D}\sqrt{N-1}}{S_D}$$

$$t = \frac{\frac{259.5}{20}\sqrt{20-1}}{\sqrt{\frac{4013.25}{20} - \left(\frac{\Sigma D}{N}\right)^2}}$$

$$t = \frac{12.97 \times 4.36}{\sqrt{200.66 - 168.22}}$$

$$t = \frac{12.97 \times 4.36}{\sqrt{32.44}}$$

$$t = \frac{56.55}{\sqrt{32.44}}$$

$$t = \frac{56.55}{5.695}$$

$$t = 9.929^*$$

*Significant beyond .01 per cent level of confidence.

Where:

$$t = \frac{\bar{D}\sqrt{N-1}}{S_D}$$

$$\bar{D} = \frac{\Sigma D}{N}$$

N = Number of scores

$$S_D = \sqrt{\frac{\Sigma D^2}{N} - \left(\frac{\Sigma D}{N}\right)^2}$$

APPENDIX F

INITIAL AND FINAL RAW SCORES* OF ARM STRENGTH AND COMPUTATIONS FOR SIGNIFICANCE FOR COLLEGE MEN WHO PRACTICED ISOMETRIC EXERCISES AND THROWING A SOFTBALL FOR DISTANCE

SUBJECTS	Pre-test	Post-test	Difference	Difference^2
1	35.	50	15.	225.
2	32.	40	8.	64.
3	22.5	34	11.5	132.25
4	24.	42	18.	324.
5	15.	34	19.	361.
6	35.	55	20.	400.
7	38.	53	15.	225.
8	47.	71	24.	576.
9	30.	39	9.	81.
10	30.	47	17.	279.
11	45.	52	7.	49.
12	25.	30	5.	25.
13	26.5	46	19.5	380.25
14	45.	50	5.	25.
15	27.	36	9.	81.
16	40.	44	4.	16.
17	35.	46	11.	121.
18	42.	56	14.	196.
19	25.	42	7.	49.
20	52.	66	14.	196.
			$\Sigma D=252.0$	$\Sigma D^2= 3805.50$

*Scores are given in pounds.

APPENDIX F (continued)

$$t = \frac{\bar{D}\sqrt{N - 1}}{S_D}$$

$$t = \frac{\frac{252}{20}\sqrt{20 - 1}}{\sqrt{\frac{3805.5}{20} - \left(\frac{252}{20}\right)^2}}$$

$$t = \frac{12.6 \times 4.36}{\sqrt{\frac{3805.5}{20} - \left(\frac{252}{20}\right)^2}}$$

$$t = \frac{54.94}{\sqrt{190.275 - 158.76}}$$

$$t = \frac{54.94}{\sqrt{31.52}}$$

$$t = \frac{54.94}{5.614}$$

$$t = 9.786^*$$

*Significant beyond .01 per cent level of confidence.

APPENDIX G

INITIAL AND FINAL RAW SCORES* OF ARM STRENGTH AND COMPUTATIONS FOR SIGNIFICANCE FOR COLLEGE MEN WHO PRACTICED THROWING A SOFTBALL FOR DISTANCE

SUBJECTS	Pre-test	Post-test	Difference	Difference^2
1	30	31	1	1
2	25	26	1	1
3	17.5	20	2.5	6.25
4	45	45	0	0
5	31	34	3	9
6	35	37	2	4
7	29	25	-4	16
8	33	25	-8	64
9	36	30	-6	36
10	32	41	9	81
11	17	24	7	49
12	18	21	3	9
13	27.5	40	12.5	156.25
14	27.5	28	.5	.25
15	22.5	26	3.5	12.25
16	40	35	-5.	25
17	32	32	0	0
18	13	20	7	49
19	21	24	3	9
20	36	41	5	25
			$\Sigma D = 37.0$	$\Sigma D^2 = 553.00$

*Scores are given in pounds.

APPENDIX G (continued)

$$t = \frac{\bar{D}\sqrt{N - 1}}{S_D}$$

$$t = \frac{\frac{37}{20}\sqrt{20 - 1}}{\sqrt{\frac{553}{20} - \left(\frac{37}{20}\right)^2}}$$

$$t = \frac{1.85 \times 4.36}{\sqrt{27.65 - 1.85^2}}$$

$$t = \frac{1.85 \times 4.36}{\sqrt{27.65 - 3.423}}$$

$$t = \frac{8.066}{\sqrt{24.237}}$$

$$t = \frac{8.066}{4.923}$$

$$t = 1.638*$$

*Not significant at .01 per cent level of confidence.

APPENDIX H

INITIAL AND FINAL RAW SCORES* OF ARM STRENGTH AND COMPUTATIONS FOR SIGNIFICANCE FOR COLLEGE MEN WHO DID NOT PRACTICE ISOMETRIC EXERCISES AND DID NOT PRACTICE THROWING A SOFTBALL FOR DISTANCE

SUBJECTS	Pre-test	Post-test	Difference	Difference^2
1	28	30	2	4
2	30	32	2	4
3	31	40	9	81
4	40	40	0	0
5	37	37	0	0
6	46	40	-6	36
7	23	26	3	9
8	24	24	0	0
9	25	24	-1	1
10	17.5	17	- .5	.25
11	51	50	-1	1
12	39	35	-4	16
13	40	41	1	1
14	20	20	0	0
15	29	25	-3	9
16	42.5	40	-2.5	6.25
17	34	30	-4	16
18	27	25	-2	4
19	32.5	32.5	0	0
20	27.5	26	-1.5	2.25
			$\Sigma D = -8.5$	$\Sigma D^2 = 190.75$

*Scores are given in pounds.

APPENDIX H (continued)

$$t = \frac{\bar{D}\sqrt{N-1}}{S_D}$$

$$t = \frac{\frac{-8.5}{20}\sqrt{19}}{\sqrt{\frac{190.75}{20} - \left(\frac{-8.5}{20}\right)^2}}$$

$$t = \frac{-.43 \times 4.36}{\sqrt{9.538 - .1849}}$$

$$t = \frac{-1.875}{9.353}$$

$$t = -.200^*$$

*Not significant at .01 per cent level of confidence.

APPENDIX I

INITIAL AND FINAL RAW SCORES* OF LEG STRENGTH AND COMPUTATIONS FOR SIGNIFICANCE FOR COLLEGE MEN WHO PRACTICED ISOMETRIC EXERCISES

SUBJECTS	Pre-test	Post-test	Difference	Difference^2
1	32.5	55	22.5	506.25
2	67.5	75	7.5	56.25
3	62.5	93	30.5	930.25
4	28	35	7	49
5	40	69	24	576
6	44	53	9	81
7	32.5	56	23.5	552.25
8	55	79	24	576
9	40	62	22	484
10	47.5	56	8.5	72.25
11	27.5	65	37.5	1406.25
12	45	54	9	81
13	37	52	15	2.25
14	50	58	8	64
15	52	57	5	25
16	35	48	13	169
17	50	64	14	196
18	45	49	4	16
19	58	65	7	49
20	45	62	17	289
			$\Sigma D = 308.0$	$\Sigma D^2 = 6180.75$

*Scores are given in pounds.

APPENDIX I (continued)

$$t = \frac{\bar{D}\sqrt{N-1}}{S_D}$$

$$t = \frac{\frac{308.0 \times 4.36}{N}}{\sqrt{\frac{618075.}{20} - \left(\frac{3080}{20}\right)^2}}$$

$$t = \frac{15.40 \times 4.36}{\sqrt{309.038 - 237.16}}$$

$$t = \frac{67.144}{8.478}$$

$$t = 7.919^*$$

*Indicates significance beyond .01 per cent level.

APPENDIX J

INITIAL AND FINAL RAW SCORES* OF LEG STRENGTH AND COMPUTATIONS FOR SIGNIFICANCE FOR COLLEGE MEN WHO PRACTICED ISOMETRIC EXERCISES AND THROWING A SOFTBALL FOR DISTANCE

SUBJECTS	Pre-test	Post-test	Difference	Difference^2
1	49	62	12	144
2	67.5	62	5.5	30.25
3	54	69	15	225
4	37	62	25	625
5	40	75	35	1225
6	44	70	26	676
7	27.5	48	20.5	420.25
8	44	70	26	676
9	30	37	7	49
10	75	92	17	289
11	60	74	14	196
12	35	44	9	81
13	67.5	85	17.5	306.25
14	53	57	4	16
15	52.5	54	1.5	2.25
16	55	61	6	36
17	47	66	19	361
18	45	56	11	121
19	40	52	12	144
20	45	71	26	676
			$\Sigma D = 309.0$	$\Sigma D^2 = 6299.0$

*Scores are given in pounds.

APPENDIX J (continued)

$$t = \frac{\bar{D}\sqrt{N-1}}{S_D}$$

$$t = \frac{\frac{309}{20} \times 4.36}{\sqrt{\frac{6299}{20} - \left(\frac{309}{20}\right)^2}}$$

$$t = \frac{15.45 \times 4.36}{\sqrt{314.95 - (15.45)^2}}$$

$$t = \frac{67.362}{\sqrt{314.95 - 238.703}}$$

$$t = \frac{67.362}{\sqrt{76.247}}$$

$$t = \frac{67.362}{8.731}$$

$$t = 7.715^*$$

*Significant beyond .01 per cent level of confidence.

APPENDIX K

INITIAL AND FINAL RAW SCORES* OF LEG STRENGTH AND COMPUTATIONS FOR SIGNIFICANCE FOR COLLEGE MEN WHO PRACTICED THROWING A SOFTBALL FOR DISTANCE

SUBJECTS	Pre-test	Post-test	Difference	Difference^2
1	43	49	6	36
2	75	75	0	0
3	52	60	8	64
4	58	62	4	16
5	60	61	1	1
6	47	52	5	25
7	47.5	48	.5	.25
8	45	64	19	361
9	56	57	1	1
10	38	55	17	289
11	56	56	0	0
12	57	50	13	169
13	55	67	12	144
14	50	40	-10	100
15	83	61	22	484
16	37.5	39	1.5	2.25
17	37.5	49	11.5	132.25
18	32.5	45	12.5	156.25
19	38	45	7	49
20	54	58	4	16
			$\Sigma D = 135.0$	$\Sigma D^2 = 2046.00$

*Scores are given in pounds.

APPENDIX K (continued)

$$t = \frac{\bar{D}\sqrt{N - 1}}{S_D}$$

$$t = \frac{\frac{135}{20} \times 4.36}{\sqrt{\frac{2046}{20} - \left(\frac{135}{20}\right)^2}}$$

$$t = \frac{6.75 \times 4.36}{\sqrt{102.3 - (6.75)^2}}$$

$$t = \frac{6.75 \times 4.36}{\sqrt{102.30 - 45.563}}$$

$$t = \frac{6.75 \times 4.36}{\sqrt{56.737}}$$

$$t = \frac{6.75 \times 4.36}{7.531}$$

$$t = \frac{29.43}{7.531}$$

$$t = 3.907*$$

*Significant beyond .01 per cent level of confidence.

APPENDIX L

INITIAL AND FINAL RAW SCORES* OF LEG STRENGTH AND COMPUTATIONS FOR SIGNIFICANCE FOR COLLEGE MEN WHO DID NOT PRACTICE ISOMETRIC EXERCISES AND WHO DID NOT PRACTICE THROWING A SOFTBALL FOR DISTANCE

SUBJECTS	Pre-test	Post-test	Difference	Difference^2
1	75	81	6	36
2	53	55	2	4
3	54	55	1	1
4	55	57	2	4
5	57.5	61	3.5	12.25
6	71	73	2	4
7	45	50	5	25
8	41	43	2	4
9	49	51	2	4
10	45	37	-8	64
11	75	75	0	0
12	64	54	-10	100
13	50	53	3	9
14	33	40	7	49
15	57	57	0	0
16	53	51	-2	4
17	67	70	3	9
18	43	45	2	4
19	25	28	3	9
20	49	50	1	1
			$\Sigma D = 24.5$	$\Sigma D^2 = 338.25$

*Scores are given in pounds.

APPENDIX L (continued)

$$t = \frac{\bar{D}\sqrt{N-1}}{S_D}$$

$$t = \frac{\frac{24.5}{20} \times 4.36}{\sqrt{\frac{338.25}{20} - \left(\frac{24.5}{20}\right)^2}}$$

$$t = \frac{1.225 \times 4.36}{\sqrt{16.912 - (1.225)^2}}$$

$$t = \frac{5.341}{\sqrt{16.614}}$$

$$t = \frac{5.341}{4.076}$$

$$t = 1.313^*$$

*Not significant at .01 per cent level of confidence.

APPENDIX M

ANALYSIS OF VARIANCE OF EXERCISE GROUPS

$$SS_{Trials\ WEX} = 40(111.02249 - 110.75687)^2 + (110.98249 - 110.75687)^2 + (110.68999 - 110.75687)^2 + (110.33249 - 110.75687)^2$$

$$SS_{TWEX} = 40(.13368) + (.05090) + (.00447) + (.18009)$$

$$SS_{TWEX} = 40\ (.36914)$$

$$SS_{TWEX} = 14.76560$$

$$MS_{TWEX} = \frac{14.76560}{3}$$

$$MS_{TWEX} = 4.92185$$

Where:

$$MS = \frac{SS}{3}\ \text{(degrees of freedom)}$$

$$F = \frac{4.92185}{8.37184751}$$

$$F = .5080$$

Where:

$$F = \frac{MS}{\text{Error (w)}}$$

APPENDIX N

ANALYSIS OF VARIANCE OF NO-EXERCISE GROUPS

$$SS_{TWNEX*} = 40(106.37999 - 104.94249)^2 + (105.81250 - 104.94249)^2 + (104.79250 - 104.94249)^2 + (102.78499 - 104.94249)^2$$

$$SS_{TWNEX} = 40(2.06640) + (.75691) + (.02250) + (4.65481)$$

$$SS_{TWNEX} = 40(7.50062)$$

$$SS_{TWNEX} = \frac{300.02480}{3}$$

$$MS_{TWNEX} = 133.34160$$

$$F = \frac{133.34160}{8.37184751}$$

$$F = 15.927^{**}$$

*Trials with no exercises.

**Significant beyond .01 level.

APPENDIX O

LINEAR REGRESSION COMPUTATIONS OF FINAL MEANS OF TWENTY UNDERHAND THROWS FOR COLLEGE MEN WHO WERE TERMED THE NO-EXERCISE GROUP

Test	N	df	Sums of Squares	Mean Squares
No-exercise	40	3	300.0248	133.3416
Exercise	40	3	14.7656	4.9219
Error		228	1908.7813	8.3718

1st. 20	2nd. 20	3rd. 20	4th. 20
106.38	105.81	104.79	102.78
x 40	x 40	x 40	x 40
4255.20	4232.40	4191.60	4111.20
- 3	- 1	+ 1	+ 3
-12765.60	-4232.40	4191.60	12333.60

$$-12765.60 - 4232.40 = -16998.00$$
$$+16525.20$$
$$-472.8$$

$$4191.60 + 12333.60 = +16525.20$$

$$-3^2 + -1^2 + 1^2 + 3^2 = 20$$

$$\frac{-(472.8)^2}{40(20)} = \frac{-(472.80)^2}{800} = \frac{223539.84}{800} = 279.42$$

$$F = \frac{279.42}{8.372} = 33.38*$$

$$300.024 - 279.420 = 20.604$$

$$\frac{20.604}{8.372} = 2.575**$$

*Indicates Linear Regression; significant at .01 level.

**Indicates Quadratic and Cubic Regression; not significant.

APPENDIX P

STANDARD ERROR OF MEAN COMPUTATIONS FOR ARM AND LEG STRENGTH

ARM STRENGTH

Isometric Exercise Group $= \sigma_m = \sqrt{\frac{\Sigma x^2}{N(N-1)}} = \sqrt{\frac{4013.25}{380}} = 3.25$

Isometric Exercise + Throw Group $= \sigma_m = \sqrt{\frac{\Sigma x^2}{N(N-1)}} = \sqrt{\frac{3805.50}{380}} = 3.16$

Throw Group $= \sigma_m = \sqrt{\frac{\Sigma x^2}{N(N-1)}} = \sqrt{\frac{553}{380}} = .38$

No-exercise, No-throw Group $= \sigma_m = \sqrt{\frac{\Sigma x^2}{N(N-1)}} = \sqrt{\frac{190.75}{380}} = .707$

LEG STRENGTH

Isometric Exercise Group $= \sigma_m = \sqrt{\frac{\Sigma x^2}{N(N-1)}} = \sqrt{\frac{6180.75}{380}} = 4.03$

Isometric Exercise + Throw Group $= \sigma_m = \sqrt{\frac{\Sigma x^2}{N(N-1)}} = \sqrt{\frac{6299}{380}} = 4.07$

Throw Group $= \sigma_m = \sqrt{\frac{\Sigma x^2}{N(N-1)}} = \sqrt{\frac{2046}{380}} = 2.32$

No-exercise, No-throw Group $= \sigma_m = \sqrt{\frac{\Sigma x^2}{N(N-1)}} = \sqrt{\frac{338.25}{380}} = .959$

VITA

The author was reared and received his elementary and high school education in Toluca, Illinois. Born in 1926, he graduated from high school and went into the United States Navy in 1943. He spent three years and six months in the service—twenty-seven months being spent aboard two different ships in the Pacific Theater of War Operations.

Upon his discharge from the service in 1946, he enrolled at Illinois State University where he received both Bachelor and Master of Science degrees.

In 1963, he began work on the doctoral level at Louisiana State University and the Doctor of Education degree, with a major in Physical Education, was awarded in January, 1965.

The author has had teaching experience at the elementary, junior and senior high school, and college levels. He is at present a faculty member at Illinois State University, where he is a member of the Department of Health and Physical Education.

EXAMINATION AND THESIS REPORT

Candidate: Buford Harold Bass

Major Field: Physical Education

Title of Thesis: The Effects of Isometric Exercises on Underhand Throwing Ability

Approved:

Major Professor and Chairman

Dean of the Graduate School

EXAMINING COMMITTEE:

Date of Examination:

December 5, 1964